

# Amateur Radio and Open Source (Not Just Linux)

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**[LinuxFest Northwest 2024](#)**

Post-presentation Version with Links

YouTube: <https://youtu.be/hNgTXXeIAio?si=cmwT5AQEyAchYSP6>

## Disclaimers:

- This is a “glancing blow” presentation.
- My goal is to perhaps create some interest in the LinuxFest attendees to perhaps get interested in Amateur Radio.
- By design, this isn’t a complete picture of Amateur Radio. These are one person’s *opinionated* opinions.
- Will provide links in a followup in my newsletter Zero Retries (more about that later).

## Disclaimers:

- I won't mention Linux much by name, but like industry, in Amateur Radio, Linux is the native environment for doing useful, fun, or hard things involving processors.
- All of the examples I mention, that involve a computer, are running Linux behind the scenes.
- Most examples I cite are open source (not Linux specific), so can be made to work on other platforms such as MacOS or Linux... or even BSD.

# Calibrating this talk - About N8GNJ

- *My* primary interest is in data communications and VHF / UHF operations.
  - Also “Space” and “Microwave” and “HF<sup>1</sup>”.
- Back in the day, that was packet radio.
- Now I write a newsletter called Zero Retries that talks about the technological innovation that is occurring in Amateur Radio (that you generally don’t hear about elsewhere).
- Not a developer, no longer involved in IT, not hardcore Linux user / admin (just a fan and light user).
- I Write, learn, do some experimenting - it’s all fun!

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<sup>1</sup> The Amateur Radio bands at frequencies lower than 30 MHz - also known as “Shortwave” bands.

## ***It's Amateur Radio...***

- This is the one “actionable item” in this entire presentation.
- Mostly, we call ourselves (and the FCC calls us) **Amateur Radio**.
  - *Amateur Radio Operators, Amateur Radio Service.*
- When we're feeling informal, we call ourselves Ham Radio.
  - *Lots of disputes about the origin of “Ham”.*
- Never, *ever* “Hammers” or “Hamsters” or “Hammies”.

# Amateur Radio = Open Source (Knowledge Sharing)

- I posit that Amateur Radio was the original open source technical community<sup>2</sup>.
- When Amateur Radio began formal licensing in 1912, “open source” was publication of radio equipment information in the many, many magazines.
- There wasn’t any commercial Amateur Radio equipment - it was all “homebrew”, and innovations were discussed openly at radio club meetings (like Homebrew Computer Club and computer user groups).
- Up through the 2000s, it was common for an Amateur Radio unit to include a schematic diagram (the “source code” for hardware).

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<sup>2</sup> I expound on this point at length in another YouTube video - [https://youtu.be/hVJj\\_WX-MI?si=q5llyRfjbQSSD05p](https://youtu.be/hVJj_WX-MI?si=q5llyRfjbQSSD05p) - Open Source and Amateur Radio - Steve Stroh -

# *This... is an Amateur Radio...*

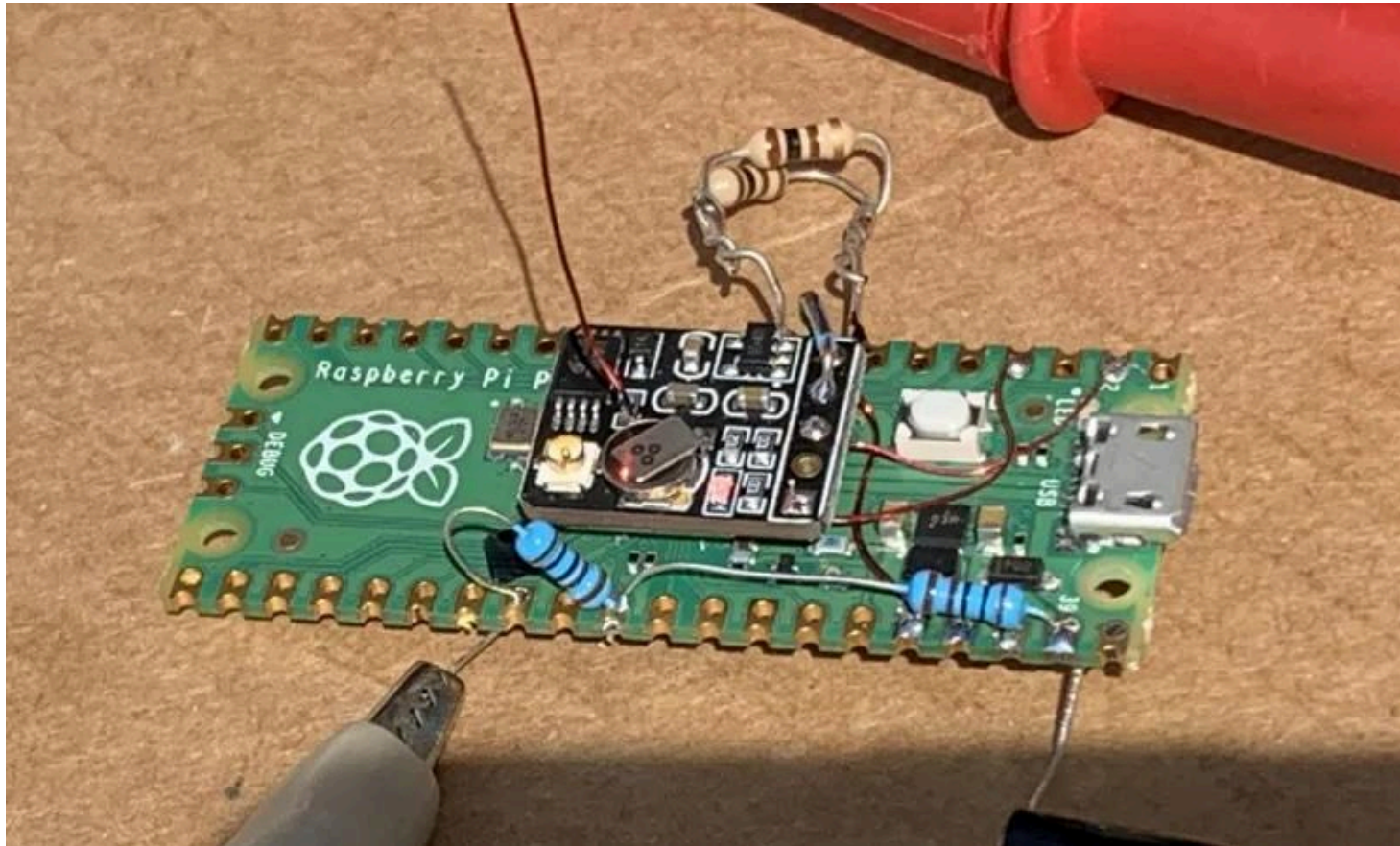


Image courtesy of Hackaday

## Balloon telemetry transmitter based on Raspberry Pi Pico

WSPR To The Wind With A Pi Pico High Altitude Balloon - <https://hackaday.com/2024/04/11/wspr-to-the-wind-with-a-pi-pico-high-altitude-balloon/>

# This... is *also* an Amateur Radio...



Image courtesy of GL-iNet

Wi-Fi Travel Router - firmware can be flashed to use AREDN

AREDN Supported Devices - [http://downloads.arednmesh.org/firmware/html/SUPPORTED\\_DEVICES.md](http://downloads.arednmesh.org/firmware/html/SUPPORTED_DEVICES.md)



**You guessed it - this *is* an Amateur Radio...**



Image courtesy of Great Scott Gadgets

General purpose Software Defined Transceiver  
HackRF One - <https://greatscottgadgets.com/hackrf/one/>

# This is yet another Amateur Radio...



Image courtesy of ZachTek

## Weak Signal Propagation Reporter “appliance”

ZachTech WSPR Desktop Transmitter - <https://www.zachtek.com/product-page/wspr-desktop-transmitter>

# And lastly, a really cute, but cool Amateur Radio



Image courtesy of WiMo

## APRS (position data) transmitter / receiver / TNC

WiMo PicoAPRS Transceiver - <https://www.wimo.com/en/picoaprs>

# Amateur Radio in the 2020s and beyond isn't your grandfather's Amateur Radio...

- US Amateur Radio's big organization<sup>3</sup> (that's supposed to be representing US Amateur Radio) has a mindset that's kind of stuck in the mid-to-late 20th Century.
- It's a social media and video world now... and US Amateur Radio's big organization is still publishing magazines.
- The "big org" doesn't cover (much) about cool, interesting, techie stuff that's happening in Amateur Radio.

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<sup>3</sup> American Radio Relay League - ARRL - <http://arrl.org/>

# Amateur Radio in the 2020s and beyond isn't your grandfather's Amateur Radio...

- Thus, no surprise that you're not hearing how cool and interesting Amateur Radio actually is in this era, and the technological innovation *occurring* within Amateur Radio.
- With some exceptions:
  - Hackaday<sup>4</sup>
  - A few YouTubers<sup>5</sup>
  - GNU Radio Conference<sup>6</sup>
  - DEF CON (Ham Radio Village)<sup>7</sup>

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<sup>4</sup> Hackaday *Radio Hacks* category - <https://hackaday.com/category/radio-hacks/>

<sup>5</sup> For my current favorites, go to <https://www.zeroretries.org/>, select the latest issue, and scroll down to the **Closing The Channel** section at the end.

<sup>6</sup> <https://events.gnuradio.org/event/24/>

<sup>7</sup> <https://hamvillage.org/>

# Amateur Radio in the 2020s and beyond isn't your grandfather's Amateur Radio...

- Can still do Morse Code if you want to.
  - Lots of company, it's a popular mode.
  - There are radios with built-in Morse Code decoder and keyboards<sup>8</sup> to send Morse Code.
  - Still used in surprising places like identifiers on aviation beacons.
  - Oldest “data mode” and it's the only one that machines and humans can understand equally well

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<sup>8</sup> PreppComm DMX-40 Morse Code Transceiver - <https://www.preppcomm.com/products/dmx-40-transceiver>

# A bit of bragging about Amateur Radio

- Ethernet was co-invented by an Amateur Radio Operator - David Boggs WA3DBJ<sup>9</sup>.
- Hayes modems were co-invented by an Amateur Radio Operator - Dale Heatherington WA4DSY<sup>10</sup>.
- Marine industry's Automatic Identification System (AIS) was inspired by Amateur Radio's Automatic Packet Reporting System (APRS)<sup>11</sup> - Bob Bruninga WB4APR.

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<sup>9</sup> Wikipedia - David Boggs - [https://en.wikipedia.org/wiki/David\\_Boggs](https://en.wikipedia.org/wiki/David_Boggs)

<sup>10</sup> WA4DSY is best known in Amateur Radio for creating the first 56 kbps radio modem for Amateur Radio - <https://www.wa4dsy.net/rfmodem.html>

<sup>11</sup> Wikipedia - Automatic Packet Reporting System - [https://en.wikipedia.org/wiki/Automatic\\_Packet\\_Reporting\\_System](https://en.wikipedia.org/wiki/Automatic_Packet_Reporting_System)

# Cool things I've been told about Amateur Radio

- An early Amateur Radio satellite was going to have a GPS receiver. When the satellite developers asked a USAF representative what the GPS signals were “outside” of the GPS orbits...
- The reply was “We can't tell you... that's classified. *But, we'd appreciate it if you would share the GPS data from your satellite with us.*”



# Cool things I've been told about Amateur Radio

- When Microsoft was considering the creation of Microsoft Network (dialup modem pools) in the early days of consumer access to the Internet...
- The networking experts said that 1200 baud modems weren't fast enough to use the TCP/IP protocol on the consumer's computers.
- Someone spoke up - "I'm a Ham Radio Operator, and I do 1200 baud TCP/IP from my house, via my ham radio. TCP/IP works fine with a little parameter tuning."

# Something cool I can tell about Amateur Radio

- My fourth job at Boeing was a SysAdmin / NetAdmin for a semi-independent group in Boeing's defense group. I was hired for that job because of my Amateur Radio experience.
- Boeing was on the Internet very early and this group used Internet. Thus, a primary qualification for this SysAdmin / NetAdmin job was you had to know TCP/IP. (Most applicants didn't.)
- I was able to say "Yes, I know TCP/IP". When they asked how... I said "I use it on Amateur Radio"<sup>12</sup>.

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<sup>12</sup> The Puget Sound Amateur Radio TCP/IP Group - <https://archive.org/details/DCC1995-WETNET-N8GNJ/mode/1up>

# A bit more bragging about Amateur Radio

## Amateur Radio in Space

- There's been an Amateur Radio station on the International Space Station<sup>13</sup> for decades.
  - Astronauts do pre-arranged contacts with schools during their personal time.
  - Radio system is left on as a flying “repeater” and “digipeater” for Amateur Radio use.
- QO-100<sup>14</sup> is an Amateur Radio payload on a GEO satellite above Africa - covers Europe and Asia.
- Japan's recent moon lander included an Amateur Radio transmitter<sup>15</sup>.
- Amateur Radio Operators regularly communicate by bouncing signals off the Moon<sup>16</sup> (passive reflector).
  - Requires a lot of skill and good equipment.

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<sup>13</sup> Amateur Radio on the International Space Station - ARISS - <https://www.ariss.org/>

<sup>14</sup> Es'hail 2 / QO-100 - <https://amsat-uk.org/satellites/geo/eshail-2/>

<sup>15</sup> World's Smallest Moon Lander from Japan will Put Ham Radio Transmitter on the Moon - <http://www.arrl.org/news/view/world-s-smallest-moon-lander-from-japan-will-put-ham-radio-transmitter-on-the-moon>

<sup>16</sup> AKA - Moonbounce or Earth-Moon-Earth; Wikipedia -Earth–Moon–Earth communication - [https://en.wikipedia.org/wiki/Earth%E2%80%93Moon%E2%80%93Earth\\_communication](https://en.wikipedia.org/wiki/Earth%E2%80%93Moon%E2%80%93Earth_communication)

# What Do Amateur Radio Operators *Do*?

The FCC says<sup>17</sup>:

- a. Recognition and enhancement of the value of the amateur service to the public as a voluntary noncommercial communication service, particularly with respect to providing emergency communications.
- b. Continuation and extension of the amateur's proven ability to contribute to the advancement of the radio art.
- c. Encouragement and improvement of the amateur service through rules which provide for advancing skills in both the communication and technical phases of the art.
- d. Expansion of the existing reservoir within the amateur radio service of trained operators, technicians, and electronics experts.
- e. Continuation and extension of the amateur's unique ability to enhance international goodwill.

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<sup>17</sup> Code of Federal Regulations, Title 47, Chapter I, Subchapter D, Part 97, Subpart A § 97.1, Basis and Purpose - <https://www.ecfr.gov/current/title-47/chapter-I/subchapter-D/part-97/subpart-A/section-97.1>

# What Do Amateur Radio Operators *Do*?

## Realities in the 2020s

Emergency communications are rapidly shifting for organizations to not need Amateur Radio. They now have:

- **FirstNET**<sup>18</sup> (hardened AT&T service for first responders).
- **Iridium** (all new, much more capable satellites<sup>19</sup> a few years ago, light data / messaging / voice / push to talk radios).
- **Starlink** is the real game changer (from limited GEO satellite service). Roll in with a trailer<sup>20</sup> and instantly be on the Internet at broadband speed.
  - VOIP, cameras, web services, Wi-Fi, radio linking.

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<sup>18</sup> First Responder Network Authority - <https://firstnet.gov/>

<sup>19</sup> "Iridium NEXT" - <https://www.iridium.com/blog/iridium-next-review/>

<sup>20</sup> Starlink for Land Mobility (Business services) - <https://www.starlink.com/business/mobility>

# What Do Amateur Radio Operators *Do*?

## Realities in the 2020s

- Although the “served agency” role is going away, Amateur Radio for *personal* emergency communications is more relevant than ever.
  - Mobile telephone networks are fragile and centralized.
    - And easily overloaded.
  - Home Internet is also fragile and centralized.
  - In a major power failure, battery backup in the communications infrastructure keeps cell sites and cable infrastructure working *for only a few hours*.
    - Analog phones working when power is out was a happy accident of technology; not replicated in new systems.
- To communicate *via Amateur Radio*, you only need power, a radio, and an antenna. It’s also nice to have a license.

# What Do Amateur Radio Operators *Do*?

## Realities in the 2020s

- Amateur Radio used to be the only legal way for a citizen of the USSR (and some other countries) to be able to communicate *directly* with a citizen of the US.
  - International Goodwill
- Now... *who doesn't* have coworkers, friends / acquaintances, family, favorite YouTuber in other countries, via the Internet, that you've never met in person.
  - International Goodwill... *at scale*.

# What Do Amateur Radio Operators *Do*?

## Realities in the 2020s

What us Amateur Radio techies and the FCC agree is still relevant in the 2020s are:

- “... advancement of the radio art.”
- “... advancing skills in both the communication and technical phases of the art.
- “Expansion of the existing reservoir within the amateur radio service of trained operators, technicians, and electronics experts.”



# What Do Amateur Radio Operators *Do*?

## Realities in the 2020s

Amateur Radio *techies*:

- Experiment
  - and *learn* from the experiments.
- Build
  - and *learn* from the process of building.
- Communicate and share ideas with your co-conspirators
  - and *learn* from the collaboration.
- Have Fun
  - and *learn* even faster when doing fun stuff.

# Software Defined Radio Has Changed Amateur Radio

- Powerful, cheap computers
- Field Programmable Gate Arrays (FPGAs)
- Digital Signal Processors (DSPs)
- Powerful embedded processors (ARM, Teensy)
- High resolution audio interfaces (“sound cards”)
- Libraries for DSP, etc.
- Inexpensive software defined receivers (RTL-SDR)
- Reasonably priced software defined transceivers
- GNU Radio framework for almost anything in radio

# A Lot of Radio Experimentation Has Shifted Into the Software Domain

Software Defined Radios is just that. For a new function, load new software:

- Transmit a new data mode
- Receive modes that used to require dedicated hardware.
- Do new things that weren't possible before SDR

Many Amateur Radio manufacturers claim “SDR” but use that as a marketing term. They won't let you “load new software”. To them, SDR = fixed function, with possible future updates.

# Amateur Radio Open Source Examples

- There are many, *many*, ***many*** open source projects in Amateur Radio.
- Many are open source *hardware* designs - radios, modems, peripherals shared freely. Schematics, Gerbers (board layouts), mechanical CAD files, even 3D printing files to build enclosures.
- But most open source projects in Amateur Radio are software.
- What follows will be a very brief, incomplete, highly subjective overview of a very few examples.

# Amateur Radio Open Source Examples

## KA9Q NET / NOS<sup>21</sup>

- Phil Karn KA9Q was one of the first to demonstrate how *real* open source software worked (the old Internet / UNIX model) to Amateur Radio.
- KA9Q Net and later NOS software was a TCP/IP stack, running on DOS, with a few drivers for hardware common in Amateur Radio, such as a “KISS”<sup>22</sup> TNC.
- Net / NOS predated Linux.

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<sup>21</sup> KA9Q NOS Package - <https://www.ka9q.net/code/ka9qnos/>

<sup>22</sup> KISS Amateur Radio Protocol - [https://en.wikipedia.org/wiki/KISS\\_\(amateur\\_radio\\_protocol\)](https://en.wikipedia.org/wiki/KISS_(amateur_radio_protocol))

# Amateur Radio Open Source Examples

## KA9Q NET / NOS

- KA9Q was a stickler for standards in TCP/IP (he has a few RFCs to his name) and his Amateur Radio TCP/IP stack worked exactly like “Internet” TCP/IP.
- Net / NOS worked fine as an Internet client if you had a SLIP or Ethernet connection.
- Net / NOS biggest contribution was proving TCP/IP could work at very low speeds - 1200 bps, half duplex, lots of lost packets. But... it... *worked*.

# Amateur Radio Open Source Examples

## Linux AX.25 Drivers

- I'm not an expert on Linux AX.25 kernel (?) drivers.
- Linux has (since the early days?) AX.25 drivers<sup>23</sup> to enable Amateur Radio “TNCs” (packet radio modems) to operate as just another peripheral.
- Thus all Linux utilities and apps could, theoretically, operate via Amateur Radio Packet Radio, natively (no special Amateur Radio applications needed).
- AX.25 support in Linux hasn't aged well. A grant was awarded<sup>24</sup> in late 2021 to a group of European hams / Linux experts, to update Linux AX.25 support.

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<sup>23</sup>[www.kernel.org](https://www.kernel.org/doc/html/v5.19/networking/ax25.html) - Networking - AX.25 - <https://www.kernel.org/doc/html/v5.19/networking/ax25.html>

<sup>24</sup> ARDC Grant: Fixing the Linux kernel AX.25 - <https://www.ardc.net/apply/grants/2021-grants/grant-fixing-the-linux-kernel-ax-25/>

# Amateur Radio Open Source Examples

## Codec 2

- Because there was so much money to be made via patents in the mobile telephone industry, nearly *every conceivable approach* to digital voice was patented in the early days of cellular moving from analog voice to digital voice.
- Open source folks in Amateur Radio find it irritating / problematic that digital voice systems in Amateur Radio use patented (proprietary) CODECs, usually embedded in a chip (programmable DSP).



# Amateur Radio Open Source Examples

## Codec 2

- Eventually, digital voice patents expired, and other approaches to digital voice that required more compute power became practical with embedded processors.
- Amateur Radio now has access to a good, compact, open source digital voice technology called Codec 2<sup>25</sup>. In part it was developed by using techniques that were patented... but the patent had expired.
- Codec 2 is digital voice that's “pure software” and pure open source, optimized for use on Amateur Radio.

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<sup>25</sup> Rowetel - Codec 2 - [https://www.rowetel.com/?page\\_id=452](https://www.rowetel.com/?page_id=452)

# Amateur Radio Open Source Examples

## Codec 2 in FreeDV and M17

- Digital Voice using Codec 2 on HF bands (shortwave) is implemented in a system called FreeDV<sup>26</sup>, optimized for the weirdness of HF.
  - FreeDV is so robust that it works through severe interference (that wasn't possible with analog voice).
- Digital Voice using Codec 2 on VHF / UHF bands is implemented in a system called M17<sup>27</sup>.
  - “Full stack” - hardware, software, protocols
- Both projects are fully open source and actively maintained and developed.

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<sup>26</sup> FreeDV: Open Source Amateur Digital Voice - <https://freedv.org/>

<sup>27</sup> M17 - <https://m17project.org/>

# Amateur Radio Open Source Examples

## Packet Radio

- Amateur Radio has been doing reasonable data communications over the air since the mid-1980s.
- Packet Radio was first experimented with in Montreal, QC<sup>28</sup>, and then fully implemented by Vancouver Amateur Digital Communications Group (VADCG)<sup>29</sup> in Vancouver, BC.
- A group originally in Tucson, Arizona - Tucson Amateur Packet Radio (now known only as TAPR<sup>30</sup> as they're no longer involved in Packet, and not in Tucson) popularized packet radio by shipping assembled and tested units.
  - Originally the TNC-1 (based on 6809) and then the TNC-2 (based on Z-80).

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<sup>28</sup> eHam.net - 28th Anniversary of Packet Radio - <https://www.eham.net/article/13877>

<sup>29</sup> Features of the VADCG TNC+ - <https://tapr.org/pdf/CNC1986-FeaturesOfVadcgTNCplus-VE7APU.pdf>

<sup>30</sup> TAPR - About - <https://tapr.org/about/>

# Amateur Radio Open Source Examples

## Packet Radio

- The “TAPR” protocol that was developed was called AX.25<sup>31</sup> (Amateur X.25) specification, and was released publicly.
- TAPR licensed the entire design of the TNC-2<sup>32</sup> (modest fee) and licensed clones quickly emerged, including internationally.
- Packet Radio experimentation flourished with numerous variations in network protocols, access systems, etc. Even had its own magazine<sup>33</sup>!
- As part of their TNC experience, TAPR created the TAPR Open Hardware License<sup>34</sup> which is often used for creating Open Source hardware projects.

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<sup>31</sup> Wikipedia - AX.25 - <https://en.wikipedia.org/wiki/AX.25>

<sup>32</sup> TAPR - History - <https://tapr.org/history/>

<sup>33</sup> Digital Library of Amateur Radio & Communications - Packet Radio Magazine - <https://archive.org/details/dlarc?tab=collection&query=%22packet+radio+magazine%22&sort=-date>

<sup>34</sup> The TAPR Open Hardware License - <https://tapr.org/the-tapr-open-hardware-license/>

# Amateur Radio Open Source Examples

## Software Defined Radio

- You can easily imagine a Software Defined Receiver as an Analog-to-Digital converter<sup>35</sup> (A/D) - with an antenna as the input. The computer is doing all the work, absorbing all the data resulting from the A/D. What to do with that data once it gets into a computer as 0's, 1's, and the sampling rate, is purely in the software realm.
- You can easily imagine a Software Defined Transmitter as a Digital-to-Analog converter<sup>36</sup> (D/A), often with a power amplifier, and an antenna. Perhaps some circuitry to “clean up” the output for only the intended frequencies.

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<sup>35</sup> Analog Devices - Not Your Grandfather's ADC: RF Sampling ADCs Offer Advantages in Systems Design - <https://www.analog.com/en/resources/technical-articles/rf-sampling-adc-offer-advantages-in-systems-design.html>

<sup>36</sup> Analog Devices - Multiband, Multistandard Transmitter Design Using the RF DAC - <https://www.analog.com/en/resources/technical-articles/multiband-multistandard-transmitter-design-using-the-rf-dac.html>

# Amateur Radio Open Source Examples

## Software Defined Radio

- SD Receiver (hardware) is easy - many good choices<sup>37</sup> of hardware and software.
- SD *Transceiver* for < 30 MHz (hardware)<sup>38</sup> is pretty easy. Many good choices for hardware and software.
- SDT for VHF / UHF is doable<sup>39</sup>, but at very low power levels.
- The real trick for a usable SDT for VHF / UHF is usable transmit power<sup>40</sup>.

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<sup>37</sup> In my opinion, the best “bang for the buck” of a Software Designed Receiver is RTL-SDR.com units - <https://www.rtl-sdr.com/about-rtl-sdr/>

<sup>38</sup> Just one example of many - Hermes Lite - <http://www.hermeslite.com/>

<sup>39</sup> Just one example of many, but the Analog Devices ADALM-PLUTO is cost-effective and widely available -

<https://www.analog.com/en/resources/evaluation-hardware-and-software/evaluation-boards-kits/ADALM-PLUTO.html>

<sup>40</sup> I recently discovered power amplifiers made by Jim Andrews KH6HTV. Originally designed for Amateur Radio Television devices, these amplifiers accept very low drive levels like those produced by Software Defined Transceivers and output reasonable power levels. KH6HTV Product List - <https://kh6htv.com/products/>

# Amateur Radio Open Source Projects

- Dire Wolf - Software modem
- WSJT-X - Very low signal levels
- M17 Project - Digital voice / messaging
- AREDN - Amateur Radio microwave networking
- HamWAN - Amateur Radio Wireless ISP in WWA
- SatNOGS - Open source community ground station
- DigiPi - Simple Amateur Radio data appliance
- MMDVM - Multimode Digital Voice / Data Modem
- DLARC - Digital library for Amateur Radio
- ARDC - Venture capital for Amateur Radio
- 44Net VPN - A free VPN and static IPv4 address

# Amateur Radio Open Source Examples

## Dire Wolf<sup>41</sup>

- Software modem (still called “TNC”).
- Uses an audio interface<sup>42</sup> (formerly, “sound card”) and does all the packet radio functions in software on a host computer.
- Implements almost all packet radio standards.
- Includes FX.25<sup>43</sup> which is Forward Error Correction backwards compatible with AX.25.
- Includes IL2P<sup>44</sup> which is integral Forward Error Correction.
- Includes support for packet radio speeds - 9600 and faster (if modem and radio support it).

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<sup>41</sup> <https://github.com/wb2osz/direwolf>

<sup>42</sup> One example of many - Tigertronics Signalink USB - <https://tigertronics.com/signalink.htm>

<sup>43</sup> Wikipedia - FX.25 Forward Error Correction - [https://en.wikipedia.org/wiki/FX.25\\_Forward\\_Error\\_Correction](https://en.wikipedia.org/wiki/FX.25_Forward_Error_Correction)

<sup>44</sup> Wikipedia - Improved Layer 2 Protocol - [https://en.wikipedia.org/wiki/Improved\\_Layer\\_2\\_Protocol](https://en.wikipedia.org/wiki/Improved_Layer_2_Protocol)



# Amateur Radio Open Source Examples

## WSJT-X<sup>45</sup>

- New data modes proving that radio is even more amazing than we knew.
- Uses intense digital signal processing and other techniques to transmit data below the noise threshold.
- We couldn't do with radio hardware what WSJT-X does in software.
- Only possible once we had fast, reasonably priced PCs in most Amateur Radio stations.
- Weak Signal Propagation Reporter (WSPR) is one of the WSJT-X modes.

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<sup>45</sup> <https://wsjt.sourceforge.io/>

# Amateur Radio Open Source Examples

## M17 Project<sup>46</sup>

- Clean sheet of paper approach to building a VHF / UHF digital voice / messaging system from scratch.
- Designed by an Amateur Radio Operator for Amateur Radio use.
- Uses open source Codec 2 - no proprietary anything in the system; all open source.
- Entire stack - digital voice codec, protocol, text, Internet connectivity.
- Even developing radios - new projects called Remote Radio Unit<sup>47</sup>, and OpenHT<sup>48</sup> - portable Software Defined transceiver.

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<sup>46</sup> <https://m17project.org/>

<sup>47</sup> <https://github.com/M17-Project/rru-rf-hw>

<sup>48</sup> <https://m17project.org/news/openht-a-breakthrough-in-ham-radio>

# Amateur Radio Open Source Examples

## AREDN<sup>49</sup>

- **A**mateur **R**adio **E**mergency **D**ata **N**etwork
- Firmware<sup>50</sup> that can be flashed onto various Wi-Fi and Wireless ISP hardware.
- Adds mesh networking, autoconfigured DNS, IP addresses, other services automagically.
- Networks being built based on AREDN (not entirely using mesh - for performance).
- Like Wi-Fi, it's transport for interesting services that run on it - VOIP, cameras, etc.

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<sup>49</sup> <https://www.arednmesh.org/>

<sup>50</sup> Based on OpenWRT - <https://openwrt.org/>

# Amateur Radio Open Source Examples

## HamWAN<sup>51</sup>

- Started in Western Washington.
- Microwave network from Vancouver, WA to Bellingham.
- Operates on “Amateur Radio” 5.9 GHz channels.
- Unlike AREDN, HamWAN is an “engineered” static network.
- User speeds < 10 Mbps (not very wide channels).
- Only requirements to access are an Amateur Radio license, compatible equipment, and optical line of sight to a HamWAN node.
- In Bellingham, local HamWAN node is on Lookout Mountain<sup>52</sup>, pretty easy to “see”.

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<sup>51</sup> <http://hamwan.org/>

<sup>52</sup> <https://www.wta.org/go-hiking/hikes/lookout-mountain-1>

# Amateur Radio Open Source Examples

## SatNOGS<sup>53</sup>

- Open Source global network of satellite ground-stations.
- Receive-only stations by individuals for research satellites built by universities, etc.
  - Such satellites often transmit telemetry and data on Amateur Radio frequencies.
- Basically a SatNOGS station is an antenna, small software defined receiver, Raspberry Pi, Internet connection, and SatNOGS software.
- Good STEM project for individuals or classes.
  - All details on the build, including 3D printing files and building antennas, are available.

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<sup>53</sup> <https://satnogs.org/>

# Amateur Radio Open Source Examples

## DigiPi<sup>54</sup>

- Based on Raspberry Pi Zero 2 W.
- Sits in a corner, headless, connected to the radio
- Acts as a web server for laptop, tablet, or phone.
- Sit on the couch, open a web browser, and work Amateur Radio modes.
- Rewrites a number of Amateur Radio modes that weren't designed to be run in a web browser.
- Pretty easy to assemble - buy the pieces<sup>55</sup>, click it together, load the software, get it on your network.
- Not dependent on Internet or Internet services.

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<sup>54</sup> <https://craiger.org/digipi/>

<sup>55</sup> There are now some easier, plug and play options - N7EBB Radio Interface Board - <https://n7ebb.org/> and ELEKITSORPARTS New digiPi HAT - <https://elekitorsparts.com/product/new-digipi-hat-ham-radio-digi-modes-aprs-ft8-ft4-winlink-from-raspberry-pi-km6lyw-digipi-image/>

# Amateur Radio Open Source Examples

## MMDVM<sup>56</sup>

- **M**ulti **M**ode **D**igital **V**oice **M**odem
- Originally designed to allow FM repeaters to carry Digital Voice.
  - No longer had to buy proprietary digital voice repeaters like D-Star, DMR, System Fusion, etc.
- New project is MMDVM-TNC<sup>57</sup> - capable new data mode 9.6 - 38.4 kbps, with Forward Error Correction, on 20 kHz Amateur Radio channels.
- May revitalize Amateur Radio repeaters for multi mode voice / data use.

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<sup>56</sup> <https://github.com/g4klx/MMDVM>

<sup>57</sup> MMDVM-TNC Project - <https://github.com/g4klx/MMDVM-TNC>

# Amateur Radio Open Source Examples

## GNU Radio<sup>58</sup>

- In radio, the question isn't so much if you can port Linux to a new piece of radio hardware, it's whether you can port *GNU Radio* to it.
- GNU Radio is a framework... toolkit... for building simple, or complex radio functions using existing libraries of code.
- There's even a GUI - GNU Radio Companion<sup>59</sup>.
- Also a conference GRCon<sup>60</sup>.

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<sup>58</sup> <https://www.gnuradio.org/>

<sup>59</sup> GNU Radio Companion - [https://en.wikipedia.org/wiki/GNU\\_Radio#GNU\\_Radio\\_Companion](https://en.wikipedia.org/wiki/GNU_Radio#GNU_Radio_Companion)

<sup>60</sup> GRCon - <https://events.gnuradio.org/event/24/>



# Amateur Radio Open Source Examples

## Digital Library of Amateur Radio & Communications<sup>61</sup>

- DLARC is a grant funded project to bring in Amateur Radio and other “communications” (very loosely defined) material to a special collection on the Internet Archive.
- Most items are free to download, others still under copyright are readable with Controlled Digital Lending.
- It’s incredibly valuable - no other “collection” like it in size or scope. Fantastic for background and tech info.
- Many books and magazines, podcasts, videos, software, etc.
  - Except stuff from “US Amateur Radio’s big organization” - but working on that<sup>62</sup>.

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<sup>61</sup> <https://archive.org/details/dlarc>

<sup>62</sup> On DLARC you can read or download the *entire 43-year run of 73 Magazine* - <https://archive.org/details/73-magazine?sort=-date>, but ARRL does not permit viewing their QST magazine without a \$60 / year paid membership.

# Amateur Radio Open Source Examples

## Amateur Radio Digital Communications (ARDC)<sup>63</sup>

- “Venture Capital” for Amateur Radio and R&D projects.
- Funded by sale of 25% of 44.x.x.x allocated for Amateur Radio in the very early days of the Internet.
- Invested prudently, generating \$5M annually for grants<sup>64</sup>.
- All new technology created using ARDC funding - hardware, software, research, etc. is required to be open source.
- Based in the US, but funding projects worldwide.

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<sup>63</sup> <https://www.ardc.net/about/mission/>

<sup>64</sup> ARDC Grant Information - <https://www.ardc.net/apply/grantmaking-categories-goals/>

# Amateur Radio Open Source Examples

## ARDC 44Net VPN<sup>65</sup>

- 44Net<sup>66</sup> is free static IPv4 addresses for Amateur Radio and research use.
- VPN is still in development, but sounds promising.
- Will let you use a static IPv4 address block by simple VPN appliance.
- Must adhere to terms of use.
- Only for Amateur Radio Operators or other qualified individuals or orgs.
- Not for commercial use.
- If you're an Amateur Radio Operator, great for homelab.

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<sup>65</sup> <https://daily.hamweekly.com/2024/02/ardc-testing-vpn-service/>

<sup>66</sup> <https://www.ardc.net/44net/>

# Amateur Radio Open Source Examples

## I could keep talking...

- Computer and Telemetry System (CATS)<sup>67</sup> - brand new data communications system.
- KiwiSDR<sup>68</sup> - Worldwide network of web radio receivers.
  - Just got mine this week!
- New Packet Radio<sup>69</sup> - up to 1 Mbps on VHF / UHF channels.
- HamSCI<sup>70</sup> - Public participation in atmospheric and space weather science. Very active during the recent eclipse to study the ionosphere.
- Balloon tracking<sup>71</sup> - Amateur Radio has the largest beacon receiver network - APRS<sup>72</sup>.

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<sup>67</sup> <https://cats.radio/>

<sup>68</sup> <http://kiwisdr.com/>

<sup>69</sup> <https://hackaday.io/project/164092-npr-new-packet-radio>

<sup>70</sup> <https://hamsci.org/>

<sup>71</sup> SondeHub - <https://amateur.sondehub.org/#!mt=Mapnik&mz=3&qm=12h&mc=56.94497,-90.79102>

<sup>72</sup> <https://aprs.fi>

# What's in it for *You*?

## Why should you care about Amateur Radio?

- An Amateur Radio license<sup>73</sup> is literally a license to experiment with radio technology.
- Significantly experiment; can (carefully) transmit high power (up to 1000 watts)...
  - Though you rarely want to / need to.
- Wide range of frequencies - down near the AM broadcast band, up to THz.
- A few basic rules, but nothing too onerous, except no encryption.
  - I'm told encryption is being seriously discussed.

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<sup>73</sup> Wikipedia - Amateur Radio Licensing in the United States - [https://en.wikipedia.org/wiki/Amateur\\_radio\\_licensing\\_in\\_the\\_United\\_States](https://en.wikipedia.org/wiki/Amateur_radio_licensing_in_the_United_States)  
Steve Stroh N8GNJ

# Amateur Radio License - How?

- Published pool of 500 questions and answers<sup>74</sup>.
  - Basic technology, rules, radio science.
  - Techies can easily “study the test”<sup>75</sup> and pass.
- Technician test (easy for techies)<sup>76</sup> gets you 100% operating privileges on all bands above 50 MHz.
- Pro tip - also take the General test, almost as easy as Tech and gets you 98% of all Amateur Radio spectrum.
- Extra is a little hard - I still haven't passed it.
- Can take tests online or in person<sup>77</sup>.
- When you pass, you need to establish an account at the FCC, pay a \$35 fee<sup>78</sup>, and your callsign is issued electronically. Good for 10 years.

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<sup>74</sup> Technician, General, and Extra Question Pools - <http://arrl.org/question-pools>

<sup>75</sup> One of the best ways to understand the Amateur Radio question pool are Dan Romanchik KB6NU's **No Nonsense! Study Guides** - <https://www.kb6nu.com/study-guides/>.

<sup>76</sup> Dan Romanchik KB6NU offers his No Nonsense! Technician Study Guide as a free PDF -

<https://www.kb6nu.com/wp-content/uploads/2023/03/2022-no-nonsense-tech-study-guide-v2-20230204.pdf>

<sup>77</sup> ARRL - Find an Amateur Radio License Exam in Your Area - <https://www.arrl.org/find-an-amateur-radio-license-exam-session>

<sup>78</sup> ARRL - FCC Application Fee Instructions - <https://www.arrl.org/fcc-application-fee>

# Amateur Radio Club in Bellingham

- Mount Baker Amateur Radio Club (MBARC).
- [mbarc.org](http://mbarc.org) (redirects).
- General interest Amateur Radio club, meets monthly, has a mailing list.
- Has a [Digital Group](#) - also meets monthly.
- Operates a number of [FM repeaters](#) in the area.
- Field Day in Blaine waterfront park Saturday June 22.

# Zero Retries Newsletter

- My weekly newsletter, published every Friday at 15:30 Pacific.
- This Saturday... *just* shy of 1600 subscribers.
- Stuff I find cool and interesting in Amateur Radio (and related).
- Free as in beer, but can also do a paid subscription for support. Full archives available, with search.

[www.zeroretries.org](http://www.zeroretries.org)



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